Attachment C. Individuals to whom the mussel habitat suitability questionnaire was submitted, July 1994.

Steven Ahlstedt, Tennessee Valley Authority *(Responded)*
Jayne Brim-Box, NBS, Southeastern Biological Science Center, Gainesville, FL
Ronald Cicerello, Kentucky State Nature Preserves Commission
Kevin S. Cummings, Illinois Natural History Survey, Champaign, IL
John A. Downing, Dept. of Biological Sciences, University of Montreal
Jim Duckworth, @ Ecological Specialists, Inc., St. Peters, MO
Heidi Dunn, Ecological Specialists, Inc., St. Peters, MO *(Responded)*
Don Hubbs, TN Wildlife Resources Agency, Nashville, TN
John J. Jenkinson, Tennessee Valley Authority *(Responded)*
Leroy Koch, USFWS, Ecological Services Field Station, Daphne, AL
James B. Layzer, TN Coop. Fisheries Research Unit, Cookeville, TN *(Responded)*
David McKinney, TN Wildlife Resources Agency, Nashville, TN
Andrew Miller, USACOE, Waterways Expt. Station, Vicksburg, MS *(Responded)*
Richard Neves, VA Coop. Fish and Wildlife Res. Unit, Blacksburg, VA *(Responded)*
Barry Payne, USACOE, Waterways Expt. Station, Vicksburg, MS *(Responded)*
Jim Sickel, Biology Department, Murray State University
Pam Thiel, USFWS, Winona, MN *(Responded)*
William Tolin, USFWS, Elkins, WV *(Responded)*
G. Thomas Watters, Div. of Wildlife, Ohio Dept. of Natural Resources *(Responded)*
James D. Williams, NBS, Southeastern Biological Science Center, Gainesville, FL
Robert Todd, TN Wildlife Resources Agency, Nashville, TN *(Responded)*

<u>Individuals who reviewed a summary of questionnaire responses:</u>
Richard Biggins, USFWS, Asheville, NC
Jayne Brim-Box, NBS, Southeastern Biological Science Center, Gainesville, FL
Robert Butler, USFWS, Jacksonville, FL
Paul Hartfield, USFWS, Listing Field Station, Jackson, MS
James D. Williams, NBS, Southeastern Biological Science Center, Gainesville, FL

Mary,

I can give you my observations on places I have sampled on the Tennessee and Cumberland rivers, but I don't think that it will apply to navigation traffic on the Ohio River.

The Army Corp has to periodically dredge high spots where substrate has washed into the navigation channels of the Tennessee and Cumberland. Some mussels can be found in these areas where they have washed in during periods of high flows. Typically, these areas are largely devoid of mussels because they have been previously dredged and the amount of navigation traffic keeps these areas disturbed. Around the periphery of the navigation channel, I have observed mussels which are typically old. This may be from the effects of prop wash or the thumping noise produced by tow propellors which have chased off potential host fish or have caused the mussel to prematurely abort glochidia because of the turbulence and noise. This is just an observation on my part and needs to be studied. The farther away you get from the navigation channel into the overbanks of the river, especially the Tennessee River downstream from Pickwick Dam, mussel reproduction and densities increase significantly. I might add that the mussel fauna in the Tennessee and Cumberland rivers especially in the upper parts of these rivers has stopped reproducing for a number of species. This surely is not the result of navigation traffic but perhaps a combination of many factors related to impoundments.

I cant't comment on navigation traffic in the Ohio River. I would think that if navigation lines are established for commercial traffic then only those areas where the navigation traffic occurs would be affected. All the mussels you have mentioned occur at varying depths in the substrate. I dont't know of anyone who has measured the depths at which these animals occur in the substrate, especially in large rivers. More importantly, all these species move up into the upper levels of the substrate to spawn. That is when they are the most likely to be blown around by barge traffic.

I think you have a formidable task ahead of you in trying to model or predict the affects caused by barge traffic. I would think that eventually the need will arise to create wider and deeper navigation channels throughout all our navigable waterways in order to accomodate larger tows. I would view this as a serious problem in the future.

I am sorry that this is such a hurried response and I wish you well with your model.

Best regards,

Steven Ahlstedt

(Reduced with unanswered questionnaire)

ECOLOGICAL SPECIALISTS, INC.
Inventories ▼ Problem Solving ▼ Impact Assessment
Heidi L. Dunn
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cal Specialists, Inc.
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October 2, 1994

Heidi L. Dunn
#95 Algana Ct.
St. Peters, MO 63376
314-447-5355

Ms. Mary Freeman
Auburn Field Station
National Biological Survey
108 Swingle Hall
Auburn University, AL 36849-5419

Dear Mary:

Following are answers to your survey questions. Most researchers agree that some species bury into the substrate more completely than others, and smaller animals generally bury more completely than larger animals. Season also affects whether an animal is found prone on or buried in the substrate and an animal's ability to rebury if disturbed. However, I do not think anyone is working on exact vertical distribution of species or size classes. Each animals depth in the substrate may be more dependent on substrate compaction than any of the above factors.

Vertical Distribution

1. We generally excavate 15 cm of substrate in our quantitative unionid samples. We find most unionids in this area. However, this depends on substrate compaction and interstitial flow. If substrate is loose but clean and stable (food and flow through gravel) unionids may live deeper.

2. Vertical distribution varies with species. *Obliquaria reflexa*, *Truncilla truncata*, and *Quadrula pustulosa* generally occur at a higher frequency in substrate samples than in visual searches.

3. Vertical distribution varies with size class. Smaller animals occur with greater frequency in substrate samples that in visual searches.

Our experience is generally that about 25-33% of unionids will be visible (some portion of the animal visible above the substrate). The remaining unionids are generally completely buried. However, the animals buried depth depends upon substrate compaction and interstitial flow. In addition, our data is limited to qualitative samples (visible animals) or quantitative substrate samples (animals in the top 15 cm of substrate). I don't know of any studies that quantify vertical distribution.

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Mortality Rates

1. Yes
2. Yes

Some species appear to be more active than others and are more likely to rebury quickly following disturbance. *Anodonta grandis, Lampsilis cardium, Leptodea fragilis*, and *Potamilus alatus* are examples of species that tend to rebury quickly. Young animals are also typically more active than older animals and more likely to rebury following disturbance. No data however is available on mortality of those species and size classes that do not rebury.

Other Considerations

Season should be considered. Most species are found prone on the substrate surface while spawning and may be more susceptible to disturbance. Also, unionids are not as active in winter and may not rebury as readily as they might during other seasons.

Shell shape may also be important. Smooth, elongated shells may be more adapted to burying while sculptured and pustulose species may be more adapted to maintaining their position in the substrate. Tom Watters, currently with Ohio Department of Natural Resources in Columbus, Ohio, completed his dissertation on shell shape and sculpturing and may be an additional source of information.

Although information is unavailable to answer your questions specifically, I hope the information I provided can somehow be incorporated into your model. We are currently trying to investigate factors such as substrate compaction, unionid occurrence, and percentage of unionids buried in some of our surveys and relocation projects. However, most of this data is observational and currently uncompiled. As we compile information I will forward it to you.

I apologize for not returning these responses sooner. If you have any questions or comments, please feel free to contact me.

Sincerely,

Heidi L. Dunn
President

Responses/Reactions to Mussel Questions

John Jenkinson, TVA

Initial Comments:

1. I find it very hard to focus on navigation traffic as a major factor affecting mussel survival when zebra mussels are rapidly being introduced into all of the surviving large-river mussel habitats.

2. Much in this entire package seems to assume that gravel mussel habitats are all uniformly compacted. That does not agree with my experience. Where the bottom materials are pliable enough, adults of many mussel species occur buried until only the siphons are exposed to flowing water. Where the bottom is more firm, larger mussels may be much more exposed.

3. Various tidbits of research and field observations suggest that juvenile mussels behave differently from the adults. So far as I know, no one has pulled all of the pieces together and described exactly what juvenile mussels do for the first year of their lives. Generally, the following comments exclude whatever the juveniles might be doing.

4. I am becomming increasingly convinced that native mussels have fairly substantial behavioral patterns and those patterns vary a good bit among the species. Unfortunately, very few studies and fewer people have documented the behavioral variations which occur in this ancient group of aquatic species.

Vertical Distribution Questions:

1. 15 cm, assuming you are asking for that depth above which any part of a live, adult mussel would be found. With siphons exposed to flowing water, 15 cm is the depth beyond which the foot of very few large mussels would extend.

2. Not really. Adults of a few species seem to prefer to have more of their shells exposed to flowing water (at least during parts of the year) but that difference has little effect on how deep into the substrate animals of a given size would go.

3. No. I have not observed adult mussels to make vertical movements down into the substrate under any sort of normal conditions.

Proportion estimate - (????) With the exception of juvenile mussels, my experience suggests that all adults orient so their siphons have access to flowing water. Depending on the roughness and firmness of the gravel/rubble bed, mussels will be located to maintain their siphoning position. If the substrate is not firmly compacted, most animals will extend into the bottom to the full length of their shells. This depth will vary by species and size of the individual.

Jenkinson Input
2

Mortality Rates

1. Yes, some species seem much more capable of reburrowing than others. In my experience, the Pleurobemas and Fusconaias are least likely to reburrow, Lampsilis and Villosas the most.

2. Yes. In general, I would expect larger specimens to have more trouble reburrowing, especially in firm substrates.

Other Considerations

Seasonal Vertical Profiles ?
Maybe, but not as any sort of high priority.

Seasonal Mortality Profiles?
No. Reburrowing behavior seems to kick in after a disturbance regardless of season or water temperature.

So far as the mussels are concerned, I would expect dislodgement and reburrowing differences to be controlled by individual size, weight, shell roughness, and (last) behavior. All but the last of these factors are strictly physical determinants, relatively easy for engineers to model. Behavior may negate all of the other factors in specific situations, but it is also the least well known and should not be invoked until more obvious components have been exhausted.

If there is a continuing reason to evaluate the effects of navigation traffic on mussels, it might be more appropriate to explore the physical effects of velocity surges on substrate stability and compaction. If the nature of the substrate changes as more or larger engines pass by, it would be logical to assume the quality and density of the resident mussel community also would change.

Please call with any requests for clarification or other opinions.

John Jenkinson
TVA, CST 17C-C
Chattanooga, TN 37402
Phone 615/751-6903
FAX 615/751-7479

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NATIONAL BIOLOGICAL SURVEY

TENNESSEE COOPERATIVE FISHERY RESEARCH UNIT
TENNESSEE TECHNOLOGICAL UNIVERSITY
PO BOX 5114
COOKEVILLE, TENNESSEE 38505

July 27, 1994

Mary Freeman
National Biological Survey
Auburn Field Station
108 Swingle Hall
Auburn University AL 36849-5419

Dear Mary:

I attempted to answer the questions as best as I could but my responses may not be very helpful. Some of my responses are basically "gut feelings". If you choose to not include me in future evaluation rounds I fully understand, but please keep me appraised of developments; I am very interested in how this all turns out. Good luck.

Sincerely,

James B. Layzer, PhD
Assistant Unit Leader

bfh

enclosure

PHONE 615/372-3094 or FAX 615/372-6257

DEPARTMENT OF THE ARMY
WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS
3909 HALLS FERRY ROAD
VICKSBURG, MISSISSIPPI 39180-6199

REPLY TO
ATTENTION OF

Environmental Laboratory

Ms. Mary Freeman
United States Department of the Interior
Auburn Field Station
108 Swingle Hall
Auburn University, Alabama 36849-5419

Dear Ms. Freeman:

I appreciate receiving a copy of the document, "Effects of Commercial Navigation Traffic, Environmental Modeling," that describes the Navigation Predictive Analysis Technique (NAVPAT), developed by personnel of the U.S. Army Engineer District, Louisville. Dr. Barry Payne and I have reviewed the document. We will not respond to the questionnaire on NAVPAT but will comment on the questionnaire and the NAVPAT (see enclosure).

If you require more information, please contact me at 601/634-2141 or Dr. Payne at 601/634-3837.

Sincerely,

Andrew C. Miller, PhD
Research Limnologist
Aquatic Ecology Branch

Enclosure

Comments on
Effects of Commercial Navigation Traffic
Environmental Modeling

Depth Distribution of Mussels in a Gravel Bar. The questionnaire requests an estimate of the depth distribution of mussel species in gravel substratum. Normally, all species of unionidae are positioned vertically with the posterior 10-25% out of the substratum so the siphons are in contact with water. Occasionally, divers report that mussels appear to be completely buried, and often mussels are found lying on their sides on top of the substratum. These differences in position are probably affected by substratum type, water velocity, mussel density, and perhaps even presence of previous shell collectors who threw mussels back in the water. None of the questions under the section "Vertical Distributions" should be addressed by the Delphi method. In theory, a study could be designed that would gather this information empirically; however, results of such a study would probably not be meaningful.

The most appropriate way to approach this problem would be to assume that adults of long, narrow mussels (such as *Ligumia recta*) probably have different susceptibility to being eroded from the substratum than juveniles of all species or adults of species that are oval (such as *Quadrula* spp.). However, none of our field studies have ever indicated that passage of commercial traffic causes this degree of disruption of the substratum (see below). Regardless, an estimate of susceptibility by species should be based on experimental results or calculations based on organism morphometries, not the Delphi method.

Estimates of Mortality Rates. None of the questions posed under this section should be dealt with by the Delphi method. This information should be gathered through experimentation.

The Need for Models. A model should only be used if it can be shown that at least one independent variable (such as changes in water velocity) affects a dependent variable (such as mussel mortality). We have measured changes in water velocity at the substratum-water interface caused by at least 100 vessel passages in the Ohio and upper Mississippi Rivers. All of our studies were conducted at high quality mussel beds. In addition, we have reviewed results of similar studies conducted by the Illinois Natural History Survey. The changes in water velocity caused by passage of a commercial tow in the navigation lane are not of a sufficient magnitude to dislodge mussels from the substratum.

We have been studying community and population dynamics at valuable mussel beds adjacent to navigation lanes for 10 years. We have yet to find a significant relationship between physical effects of vessel passage and any biotic parameter indicative of the overall health of a mussel bed.

The Need for Habitat-Based Methods. The U.S. Army Corps of Engineers requires the use of habitat-based methods for impact assessment and mitigation planning. However, many types of scientifically credible studies can be conducted that are habitat-based and will provide the information needed for impact assessment and mitigation planning. There are other alternatives to

the Habitat Evaluation Procedures and the Instream Flow Incremental methodology.

Summary. It is inappropriate to use the Delphi method to develop a model when empirically obtained data are either already available or could be easily collected. Further research on the general effects of commercial navigation traffic are not warranted. Site specific studies on the effects of certain traffic patters on specific biota (mussels, aquatic plants, fishes, etc.) will probably always be needed. These studies should be undertaken using scientific procedures, not using models developed by the Delphi method.

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
Virginia Cooperative Fish and Wildlife Research Unit
106 Cheatham Hall, Virginia Tech
Blacksburg, Virginia 24061

MEMORANDUM

TO: Mary Freeman, NBS

FROM: Dick Neves, NBS

DATE: August 15, 1994

SUBJECT: Navigation impacts on gravel bar mussels

Enclosed are my few comments on your inquiry. I'm afraid that the information you seek (even as opinion) is so unreasonable for anyone to provide, with even a low level of certainty.

All of this effort, if intended for the Ohio River, is moot, as the zebra mussel is now in its exponential growth phase in that river. Adult mussels in the lower Ohio have zebras attached, up to 200/unionid, and that level of biofouling drastically changes the center of gravity of the unionid and its susceptibility to dislodgement from commercial navigation. In my opinion, adults of every species of mussel will be readily dislodged by hydrodynamic forces from tows and other traffic. That vulnerability to dislodgement was seen in the Great Lakes, where wave action displaced and washed ashore all infested unionids within the surf zone and below. As judged by this, my opinion is that most infested adult mussels in the upper 10 cm of substratum will be subject to displacement by navigation turbulence, and those animals will be unable to reburrow.

Before much more time is spent on this highly speculative exercise, COE, NBS, and FWS should assess the practical merits of this environmental modeling exercise, particularly if the intent is application to the Ohio River.

TO: Mary Freeman

FROM: Hartfield, ES, Jackson, MS

SUBJECT: Comments on mussel distributions in gravel substrate: responses to questions for reviewers.

1. Your table of vertical distribution is reasonable, in that it provides a wide margin of error. There are several points that need to be made.

A 0-2 cm loss of substrate would likely result in the loss of juveniles of most species less than three years of age. In other words, a loss of three years of recruitment effort.

A 10-20 cm loss of substrate would likely remove most adults of most species.

2. Mortality from the translocation of mussels between sites, with proper replacement into the substrate have been variable, ranging from quite high (>90%) to quite low (<5%). The ability of mussels to become re-embedded following displacement appears to be temperature, species, and condition dependent, and mortality from displacement would likely be much higher than that for translocation. I believe the NBS at La Crosse, WS, have assembled mortality rates for translocation. Maybe this could be used in some manner.

3. Another factor to consider is frequency of repetition of disturbance. A mussel bed can potentially recover from the loss of several cm of substrate, the loss of a significant proportion of individuals, and the loss of several years recruitment, if habitat conditions remain stable for several years thereafter. Repeated disturbance would result in a declining community where recruitment is almost totally dependent on immigration from undisturbed peripheral areas, or adult mussels washing in from other disturbed areas and successfully becoming re-embedded. Frequent events of prop wash, even without degradation of substrate would effectively eliminate natural recruitment of juveniles, due to sandblasting. Adult fitness may also be reduced by such events. Still another consideration is the fate of sediment if degradation does occur. Disturbed material may settle out of channel onto communities unaffected directly by prop wash and result in mortality and loss of recruitment.

Summary: Your data does have potential for creating models. However, the value of such models is debatable. As noted above, navigation has local effects on mussel communities due to degradation of substrate, redeposition of substrate, and sandblasting. Mussel communities, however, continue to survive in deeper channels, or peripheral channels of many navigable systems such as the Ohio River. The potential effects on the mussel community of an increase in running more and bigger barges in such a system is quite predictable: localized declines of mussel communities associated with the navigation channel, and less measurable effects on communities peripheral to the channel. It will be an additional impact to an already stressed community. However, given no other significant changes in habitat

stability and water quality, I would imagine that the community will survive, at least until the next escalation in ecosystem degradation.

Paul

U.S. FISH AND WILDLIFE SERVICE
ENDANGERED SPECIES FIELD OFFICE
ASHEVILLE, NC
Kentucky, North Carolina, South Carolina, Tennessee

FROM: Richard G. Biggins
330 RIDGEFIELD COURT
ASHEVILLE, NORTH CAROLINA 28806
TELEPHONE - 704/665-1195
FAX - 704/665-2782

DATE: October 28, 1994

TO: Mary Freeman
Auburn Field Station
108 Swingle Hall
Auburn University, Alabama 36849-5419

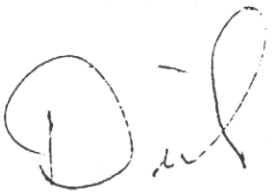
SUBJECT: Mussel distribution in gravel substrate

My comments are as follows:

- These values could be used as a guide, but it must be made clear that they are not based on much needed field measurements. Additionally, it should be made clear what these figures mean.
    - Does a vertical distribution of 0-10 cm mean that the depth the animals are found at ranges from 0-10 cm, or does it mean that the respondents' depth estimates ranged from 0-10 cm?
    - Is the mortality probability an average of the two respondents mortality estimates, or did one individual make the low probability estimates (0.3) and the other respondent make the high estimates (0.65-0.9)?.
- Question #1: The depth estimates seem reasonable, but my mussel collection experience is very limited. Steve Ahlstedt of TVA has done thousands of mussel quadrate excavations. He should be able to give you a good estimate of how far down he has found various species.
- Question #2: With only two people responding and without knowing who responded or what their estimates were based on, I can not judge the reasonableness of the estimates. Other factors that must be considered regarding mortality.
    - Are mussels covered by the substrate after they are dislodged, or are they left on the top of the substrate?
    - Are they being dislodged frequently or is this a one time event?
    - If zebra mussels are present mortality rates would likely increase as the entire surface of the mussel could then be exposed to an infestation.
- Question #3a: No

- Question #3b: Other factors - Depth of gravel substrate above bedrock or other hard surface, size of substrate particles, water velocity (in high flow areas, small mussels might be dislodged and then be swept down stream into unsuitable habitat).

Sorry I can't be of more help.



PRINTED ON RECYCLED PAPER

Comments received via fax (retyped) from Robert Butler, USFWS, Jacksonville, FL

14 October 1994

Mary -

This exercise seems to be based on much supposition. I'd be very leery of using this info. to predict impacts of barge traffic on mussel beds. We need field work to reduce the assumptions the model will be based on. If surges do contribute to high mortality by dislodging mussels, what's the answer to reduce impacts? Deeper dredging seems the only alternative. Of course, mussels would be lost either way. Relocation of the bed seems no better alternative. Again, it would seem that this is a "no-win" situation for the resource.